

Biomechanical Acclimation: Flying Cold

Why are animals reared at colder temperatures larger? A new study shows that fruit flies reared at lower temperatures are better able to fly in the cold.

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The temperature–size rule describes one of the most common patterns of phenotypic plasticity in nature: in most species, individuals reared at lower temperatures have increased adult body sizes [1]. A variety of adaptive and non-adaptive hypotheses for the temperature–size rule have been proposed, but a general explanation remains elusive [2,3]. Bergmann's rule describes a distinct but related empirical pattern found in many animal taxa: populations or species that occur in colder environments have evolved relatively larger adult sizes [4]. Many *Drosophila* follow both of these rules [5,6]. Why are flies reared at colder temperatures larger? Why do flies living in colder environments evolve larger size?

The clue to addressing these questions for flies may lie in the allometric scaling of different aspects of size. In populations of *Drosophila subobscura* on three continents, lower developmental temperatures generate large increases in wing length and wing area, but more modest changes in body mass; as a result, flies reared at lower temperatures have substantially reduced wing loading — that is, body mass/wing area ratio [5]. Gilchrist and Huey [5] suggested that this plastic response in morphology is biomechanically adaptive: reduced wing loading could facilitate flight at colder temperatures where the mechanical power output of flight muscles is reduced.

A recent study by Frazier *et al.* [7] provides an experimental test of this hypothesis in *Drosophila melanogaster*. As in earlier studies, the authors found that *Drosophila melanogaster* reared at lower temperatures had a larger wing area relative to their body size, reducing the amount of mass that must be supported by a given unit of wing. Furthermore, wing length also increased relative to body mass, even after accounting for the increase in total

wing area. This suggests that the second moment of area of the wings [8], a measure of wing shape and the best morphological predictor of slow flight capability, also increased relative to body mass.

Many factors other than wing area and length contribute to flight performance, however, so positive allometric scaling of these wing parameters is not proof of actual capability. Frazier *et al.* [7] tested flight performance directly by eliciting take offs from flies reared over a range of temperatures. Virtually all flies were able to take off at warmer environmental temperatures (18°C), but only flies reared at the coldest temperature in the study (15°C) were able to take off when the environmental temperature was reduced to 14°C. Thus, not only do flies reared at cooler temperatures have the biomechanical equipment for efficient low speed flight, they exhibit improved flight performance.

The study [7] indicates that development plasticity to cold rearing temperatures may be beneficial to flies by increasing flight performance at cold temperatures. A full demonstration of the beneficial plasticity hypothesis, however, would require evidence that flies reared at high temperatures have increased performance at high temperatures [9,10]. Why do flies reared at higher temperatures have relatively

smaller wings? Intriguingly, flies reared at lower temperatures also had a lower wingbeat frequency, a factor which should reduce forward flight speed and other aspects of flight performance. Whether this possible tradeoff provides the basis for beneficial plasticity in this or other insects will require further study.

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Axonal Domains: Role for Paranodal Junction in Node of Ranvier Assembly

A new study shows that communication between axons and glia at the paranodal junction can orchestrate the formation of the node of Ranvier.

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In the vertebrate nervous system, myelin facilitates the rapid conduction of neural impulses. Consecutive segments of myelin along the length

of an axon are separated by short unmyelinated domains, called nodes of Ranvier, which contain a high concentration of voltage-gated sodium channels that propagate the neuronal impulse. Each node of Ranvier is